[0024] Admittance control technology uses a force measurement device (loadcell) placed at the patient interface. The loadcell functions as the force feedback device in a closed loop force control system. Therefore the forces are always controlled at the patient's interface, and system non-linearities mentioned before are minimized because they occur inside the force control loop and can therefore be compensated to a large degree.

[0025] A commercial robot that uses admittance control is the HAPTICMASTER (HM) from FCS Control Systems. The FCS Control Systems' control technology originated and was patented in the late 1970s in the field of flight training and simulation to generate aircraft control forces for the pilot. It has matured over the years from a patented to a company proprietary technology. See U.S. Pat. No. 4,398,889, herein incorporated by reference in its entirety.

[0026] The HAPTICMASTER, which was designed with rehabilitation applications in mind, has low inertia such that the user doesn't feel much resistance when attempting to move the device. The low level inertial properties of the HM enable application to individuals with all levels of impairment severity including individuals with severe impairment who would otherwise be unable to move against the inertial resistance of other robotic devices. Work done at the University of Reading, England has shown that the robot is safe and can assist reaching movements to various targets in the workspace of the paretic arm following stroke (Coote and Stokes (2003) Technol. Disabil. 15: 27-34; Harwin and Hillman (2003) Robotica 21; Marinncek et al (2001) Association for the Advancement of Assistive Technology in Europe AAATE '01. Amsterdam; Washington, D.C.: IOS Press,). However, it has been employed to assist subjects in reaching movements with the upper extremity constantly supported by an external device.

[0027] Each of the robotic devices described above demonstrate the ability to use robotics as a device for implementing therapeutic training post-stroke. In addition, each of these devices is capable of measuring motion and tracking progress during training. With this current patent, we propose to generate virtual mechanical/visual environments that can simulate weightlessness or make the body or limb progressively heavier to beyond its actual weight. Using these realistic simulated environments generated by a combination of multi degree of freedom robotics and visual feedback we can measure the effect of abnormal joint torque coupling in the upper and lower extremities as well as train individuals to slowly relearn to deal with the weight of their limb or body while reaching (arm) or walking (leg).

Virtual Reality

[0028] Haptics is the science of applying tactile or force sensation to human interaction with computers. A haptic device is one that involves physical contact between the computer and the-user, usually through an input/output device, such as a joystick or data gloves, that senses the body's movements. By using haptic devices, the user can not only feed information to the computer but can receive information from the computer in the form of a felt sensation on some part of the body. This is referred to as a haptic interface. For example, in a virtual reality environment, a user can pick up a virtual tennis ball using a data glove. The computer senses the movement and moves the virtual ball on the display. However, because of the nature of a haptic interface, the user will feel the tennis ball in his hand through tactile sensations that the computer sends through the data glove, mimicking the feel of the tennis ball in the user's hand. Typical uses a haptic interface are disclosed in U.S. Pat. No. 6,636,161 (Rosenberg, issued Oct. 21, 2003) and U.S. Pat. No. 6,697,043 (Shahoian, issued Feb. 24, 2004).

BRIEF DESCRIPTION OF THE INVENTION

[0029] The invention provides a system and methods to measure, to train and/or to assist and/or to rehabilitate and/or self-rehabilitate an individual having a neurological condition that results in loss in the ability to coactivate certain muscle combinations in affected limb or similar extremety of the individual.

[0030] In one embodiment the invention provides a method for measuring, treating, and self-rehabilitating an individual having a neurological condition, the method comprising: (i) providing a system comprising mechanical means, at least one computer, display means, and interconnecting means, the mechanical means further comprising an interacting instrumented member that interacts with the body or a part thereof of the individual, a force sensor, a force generator, at least one moveable non-compliant linkage, and a base, the force sensor further being attachedly connected by the linkage to the force generator, the linkage having at least three degrees of freedom, the computer further comprising an interactive software program, and the base supporting at least one of the above; (ii) securing a body or part thereof of the individual to the interacting instrumented member; (iii) permitting the individual to move the body or part thereof to a desired position; (iv) sensing the force required to move the body or part thereof using the force sensor; (v) producing force input data using the sensed force; (vi) transmitting the force input data from the force sensor to the computer; (vii) processing the force input data using the interactive software program; (viii) transmitting the processed data to the display means whereby the display shows a virtual environment; (ix) processing the data to produce force output data; (x) transmitting the force output data to the force generator and the linkage thereby generating a force upon the interacting instrumented member and the body or part thereof, the resulting generated force upon the body or part thereof causing the muscles and nerves in the body or part thereof to be stimulated, the stimulation resulting in regaining muscle coactivation patterns and associated joint torques patterns for the individual; thereby measuring, treating, and self-rehabilitating the individual. In a preferred embodiment the neurological condition is selected from the group consisting of hemiparetic stroke, cerebral palsy, head trauma, and multiple sclerosis. In a more preferred embodiment the neurological condition results in a loss of independent joint control in the body or part thereof.

[0031] In one embodiment the body or part thereof is selected from the group consisting of a whole body, a trunk, a shoulder, a neck, a head, an arm, an elbow, a wrist, a hand, a hip, a leg, a knee, an ankle, and a foot.

[0032] In another embodiment the interconnecting means provide radio communicating signals, electrical communicating signals, photonic communicating signals, or a combination thereof, between the mechanical means, the computing means, and the display means.